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Self-compatibility in 'Paloma' Indian ricegrass

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Abstract

A species' mode of reproduction must be understood before initiating a breeding program. Indian ricegrass [*Oryzopsis hymenoides* (Roem. & Schult.) Ricker] flowers may be effectively cleistogamous or chasmogamous, but the floral structures are most consistent with self-pollination than cross-pollination. Results of a field study comparing seed production of isolated and open-pollinated 'Paloma' panicles indicate that self-incompatibility is not important. These observations suggest Indian ricegrass is primarily self-pollinated. Because Indian ricegrass has diffuse panicles and small flowers, it is difficult to make large numbers of controlled crosses. Only one seed is produced per emasculation. Furthermore, any hybrid seed produced will be difficult to germinate because of persistent seed dormancy in this species. Thus, plant breeding methods traditionally used for self-pollinated crops, which rely on artificial hybridization, would be inappropriate at this time. Collecting and evaluating native accessions should be a more effective initial strategy.

Key Words: floral morphology, *Oryzopsis hymenoides*, self-incompatibility

Improved varieties of Indian ricegrass [*Oryzopsis hymenoides* (Roem. & Schult.) Ricker] are needed for revegetation of disturbed western rangelands. Unfortunately, this bunchgrass is difficult to establish because of high seed dormancy and grazing sensitivity (Robertson 1976). The tissue morphology of the Indian ricegrass flower has been described (Kam 1974, Kam and Maze 1974), but the mode of reproduction has not been documented. Selecting a strategy for genetically improving this species requires knowledge of its mode of reproduction. Rogler (1960) noted that plants within an accession had uniform growth habits, but their germination characteristics varied widely. He did not test his suspicion that Indian ricegrass was self-pollinated. Indian ricegrass is believed to have served as a pollen parent in wide crosses with *Stipa* species in North Dakota and Colorado, suggesting that outcrossing does occur (Johnson and Rogler 1943, Weber 1957). Indian ricegrass is considered ecotypic because there is considerable genetic variation among populations, but little variation within populations (Robertson 1977, Booth et al. 1980). Such ecotypes are typical in species that are highly self-pollinated (Clements et al. 1983).

Our objectives were to determine whether the floral structures of 'Paloma' (Anonymous, 1974) Indian ricegrass are consistent with self- or cross-pollination and to estimate the degree of self-fertility in isolated panicles. This information should indicate whether 'Paloma' is primarily self- or cross-pollinated.

Materials and Methods

A field plot of established Paloma plants at Providence, Utah, was used to estimate self-fertility. Before anthesis, from 25 June to 12 Aug. 1987, 69 pairs of panicles were matched for similar maturity. Both panicles of each pair were on the same plant. One panicle per pair was bagged immediately to exclude pollen from other plants (isolated). If a few florets on a panicle otherwise acceptable as an isolated panicle had reached anthesis, they were pinched off below the glumes prior to bagging. The other panicle of the pair was bagged when glumes began to open, just before seed shattering, from 14 July to 9 Sept. 1987 (open-pollinated). On 30 Sept. 1987, all bagged panicles were harvested and the number of flowers was determined as the number of intact pairs of glumes plus number of pinched florets. Seed set percentage was determined as the number of seeds/number of intact pairs of glumes. Isolated and open-pollinated treatments were compared with a paired-difference t test (Mendenhall 1975).

Results and Discussion

Analysis of 69 pairs of isolated and open-pollinated panicles matched for maturity did not indicate the presence of self-incompatibility in 'Paloma' Indian ricegrass (Fig. 1). Bagging did not inhibit inflorescence emergence or floral development; the 2 groups did not differ significantly in the number of flowers/panicle ($P>0.10$). Open-pollinated and isolated panicles had similar percentages of seed set ($P>0.10$).

The inflorescence of Indian ricegrass is a diffuse panicle with a single floret per spikelet. Two glumes, persistent at maturity, surround the floret, which is covered by long pilose-hirsute hairs (Fig. 2). The awn is hidden by the glumes and disarticulates before seed shattering. The lemma and palea fuse into an indurate seed covering, which contributes to seed dormancy (Stoddart and Wilkinson

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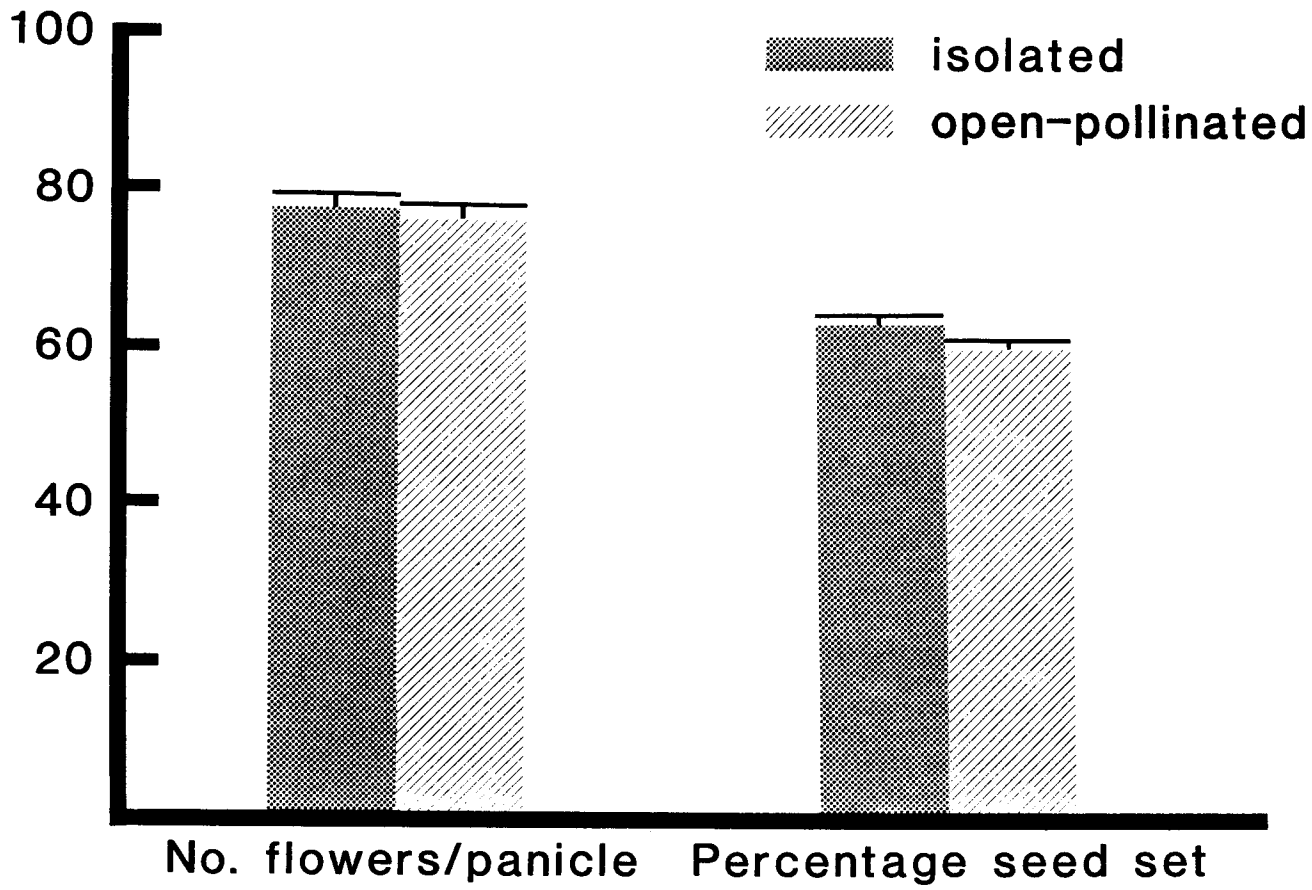

Fig. 1. *Comparison of isolated and open-pollinated Paloma panicles for mean number of flowers per panicle and percentage seed set. Bars extend 1 standard error.*

1938). Inside are 3 stamens with tetraloculate, bearded anthers (Fig. 3) and a single pistil with 2 stigmas (Fig. 4).

Increasing turgidity of the 3 lodicules (Fig. 3), vestiges of the calyx or corolla located at the base of the androecium, facilitates exsertion (Pohl 1978) by forcing open the glumes slightly (Fig. 5). The locules may dehisce along longitudinal sutures before or after the flower opens. Thus, a flower may be effectively cleistogamous or chasmogamous (Allard 1960). This appears to be environmentally controlled; there are no differences in floral morphology between the 2 groups. Dehiscence after exsertion of the anthers appears to be more common in wet or cool conditions than in dry or hot conditions, when nearly all anthers are exserted at night, already dehisced. Each locule probably contains no more than 150 pollen grains. These grains cling to the stigmas because of their plumose extensions and the stickiness of the pollen (Fig. 6). The male and female structures are proximal, regardless of whether they are exserted at anthesis or not.

The seed production data together with the morphological characteristics suggest that the Paloma Indian ricegrass flower most often pollinates itself and that seed production is not limited by self-incompatibility. While varieties of a self-pollinating species may show widely different amounts of natural hybridization (Allard 1960), outcrossing percentages would never be so high as to call a specific variety cross-pollinated. Distinct differences in mode of reproduction can be induced by extreme environments, in rare cases, but this is not a genetic effect. Thus, it is proper to consider Indian ricegrass as a whole, and not just Paloma, to be self-pollinated based on these data.

Consequently, accessions collected at native sites are probably inbred lines or mixtures of inbred lines. This explains the ecotypic nature of Indian ricegrass populations (Robertson 1976, Booth et al. 1980). This mode of reproduction is unlike that of most perennial, cool-season, forage grasses, which are nearly all cross-pollinated and are subject to varying degrees of self-incompatibility between and within species (Poehlman 1979).

The Indian ricegrass flower, however, has the potential for natural cross-pollination when it is chasmogamous. Four X *Stiporyzopsis* hybrids were found in lines derived from *S. viridula* plants (Johnson and Rogler 1943). Indian ricegrass, growing nearby in the breeding nursery, inadvertently pollinated these plants. Weber (1957) described a hybrid with *S. neomexicana* (Thurb.) Scribn. found in a pure stand of this species. No other species was present within 31 m. Such hybridization would more likely occur between 2 proximal Indian ricegrass plants, though our results suggest that this would not likely be common if both plants were male-fertile. A maternal parent's open-pollinated progeny would have to be evaluated for the presence of a genetic marker carried by neighboring pollinator plants to estimate the percentage of outcrossing.

Practical hybridization methods must be available before plant breeding can effect crop improvement. Emasculation is necessary in self-pollinated species. The diffuse panicle of Indian ricegrass obligates mechanical emasculations for each flower, though chilling and hot water emasculation have been successful in some species (Poehlman 1979). Implementation of a controlled hybridization program is further discouraged because high levels of seed dormancy mean that low percentages of the hybrid seed will ger-

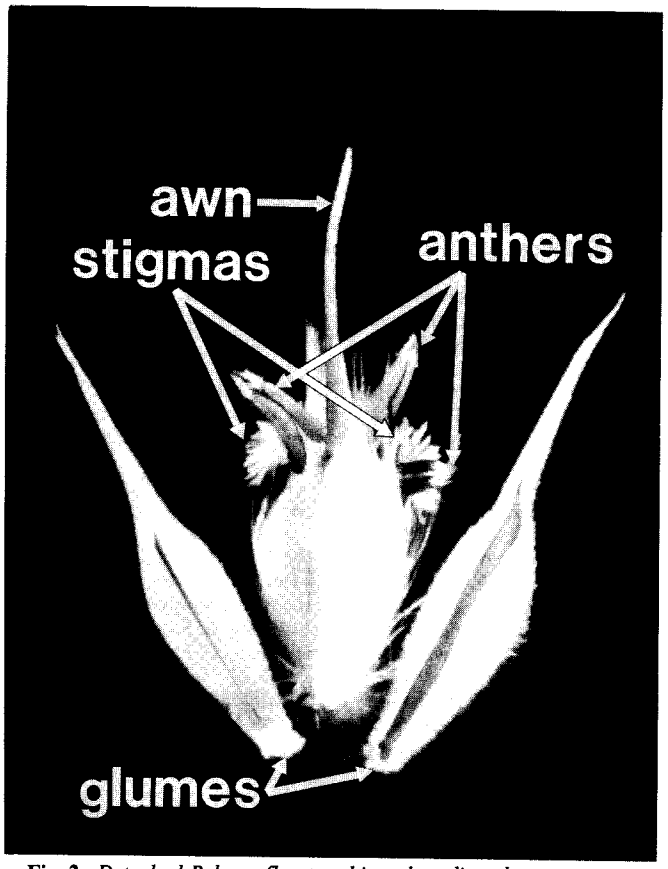

Fig. 2. *Detached Paloma floret and its subtending glumes.*

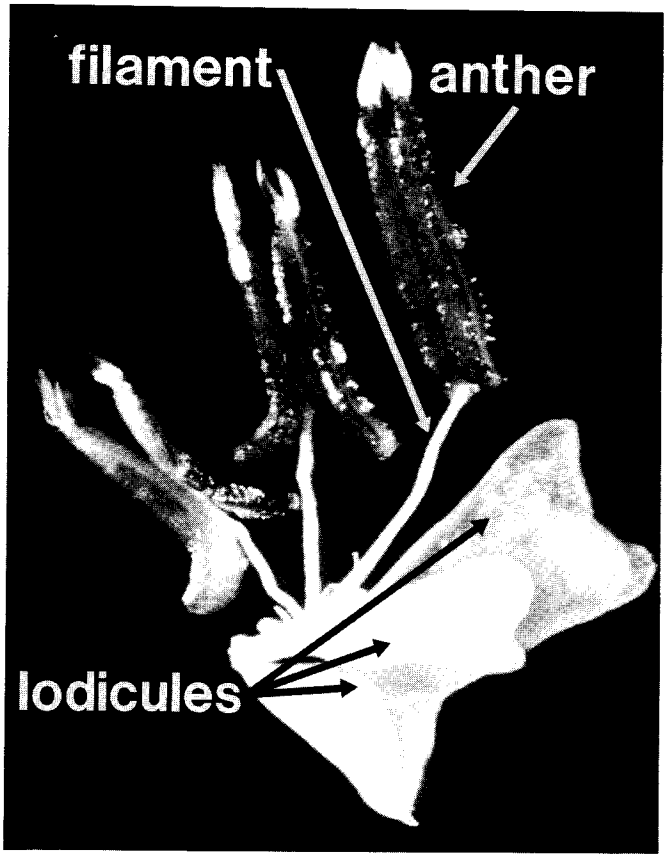

Fig. 3. *Androecium of Paloma flower with lodicules.*

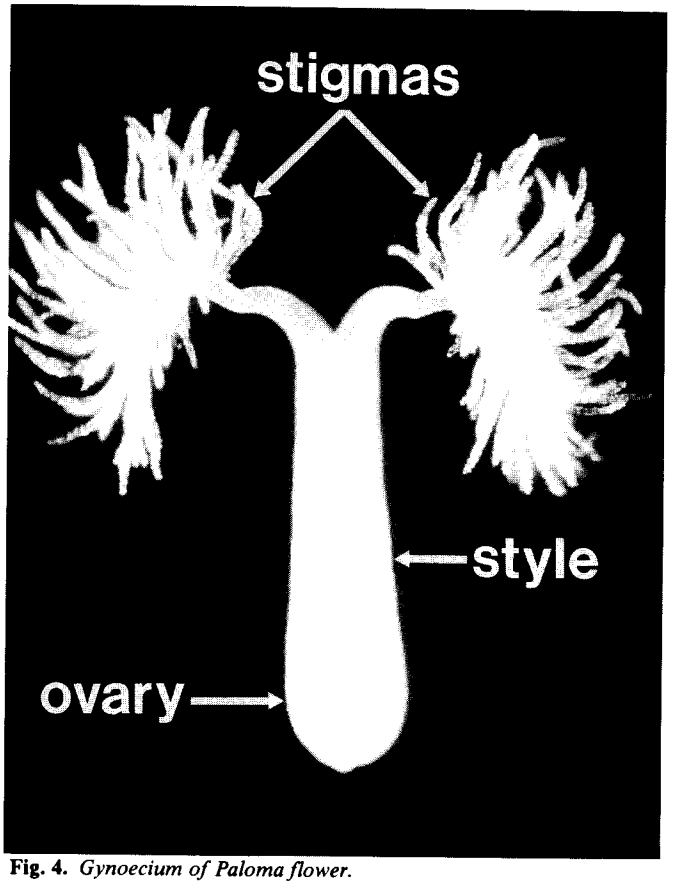

Fig. 4. *Gynoecium of Paloma flower.*

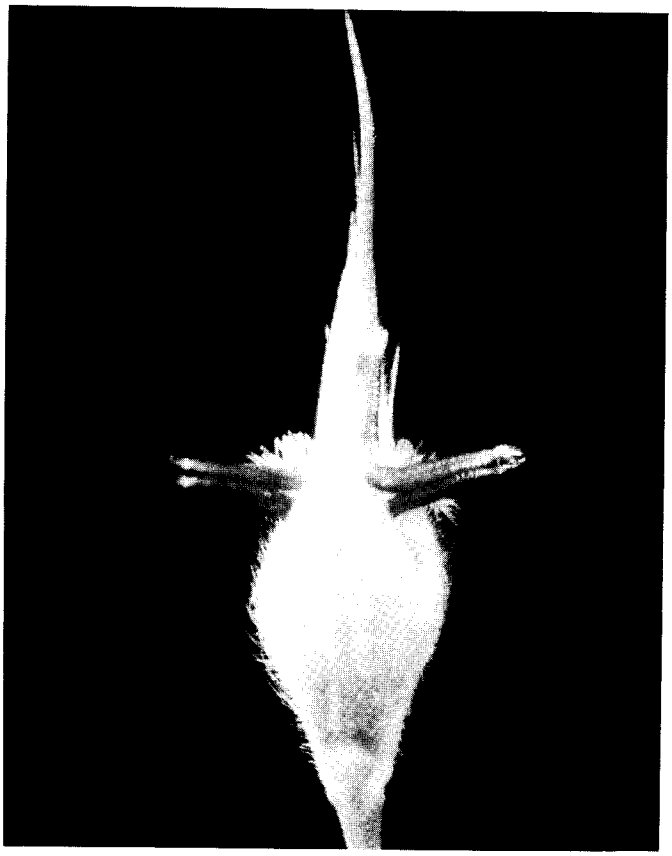

Fig. 5. *Exsertion of sexual parts of a chasmogamous Paloma flower.*

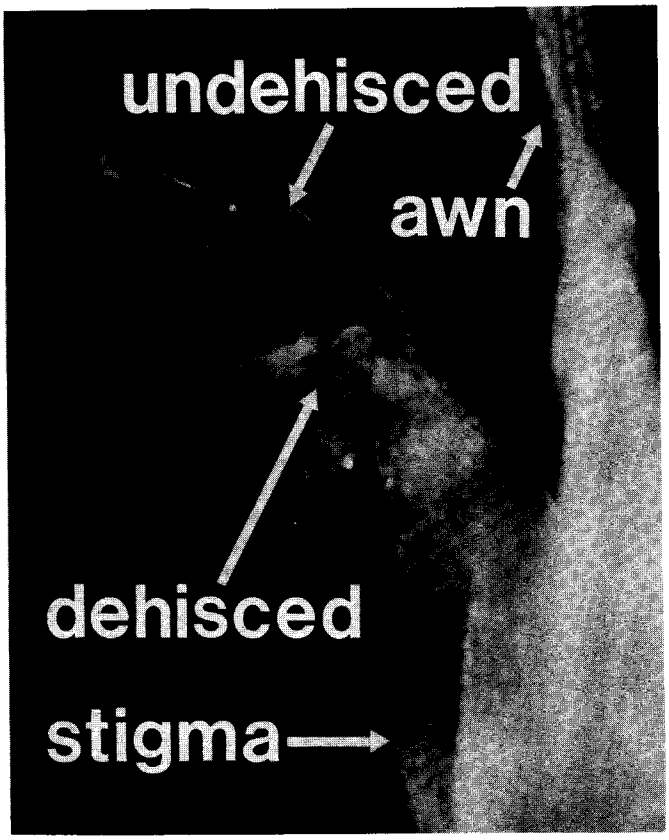

Fig. 6. *Dehisced anther lobe with sticky pollen.*

minate the year after seed harvest (Rogler 1960). Dormancy can be reduced by aging (Rogler 1960) and mechanical and acid scarification (Zemetra et al. 1983), however.

On the whole, the limitations of both controlled and natural hybridization make it difficult to generate sufficient genetic variability for successful artificial selection. It would be better to undertake a controlled hybridization program after extensive collection and evaluation, concentrating on the most promising materials for achieving our variety of development goals (Cameron 1983). Germplasm collection and evaluation has been the approach of USDA-SCS, which released Paloma (Anonymous 1974) and 'Nezpar' (Booth et al. 1980). Economic and biological considerations justify continuing the germplasm approach.

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